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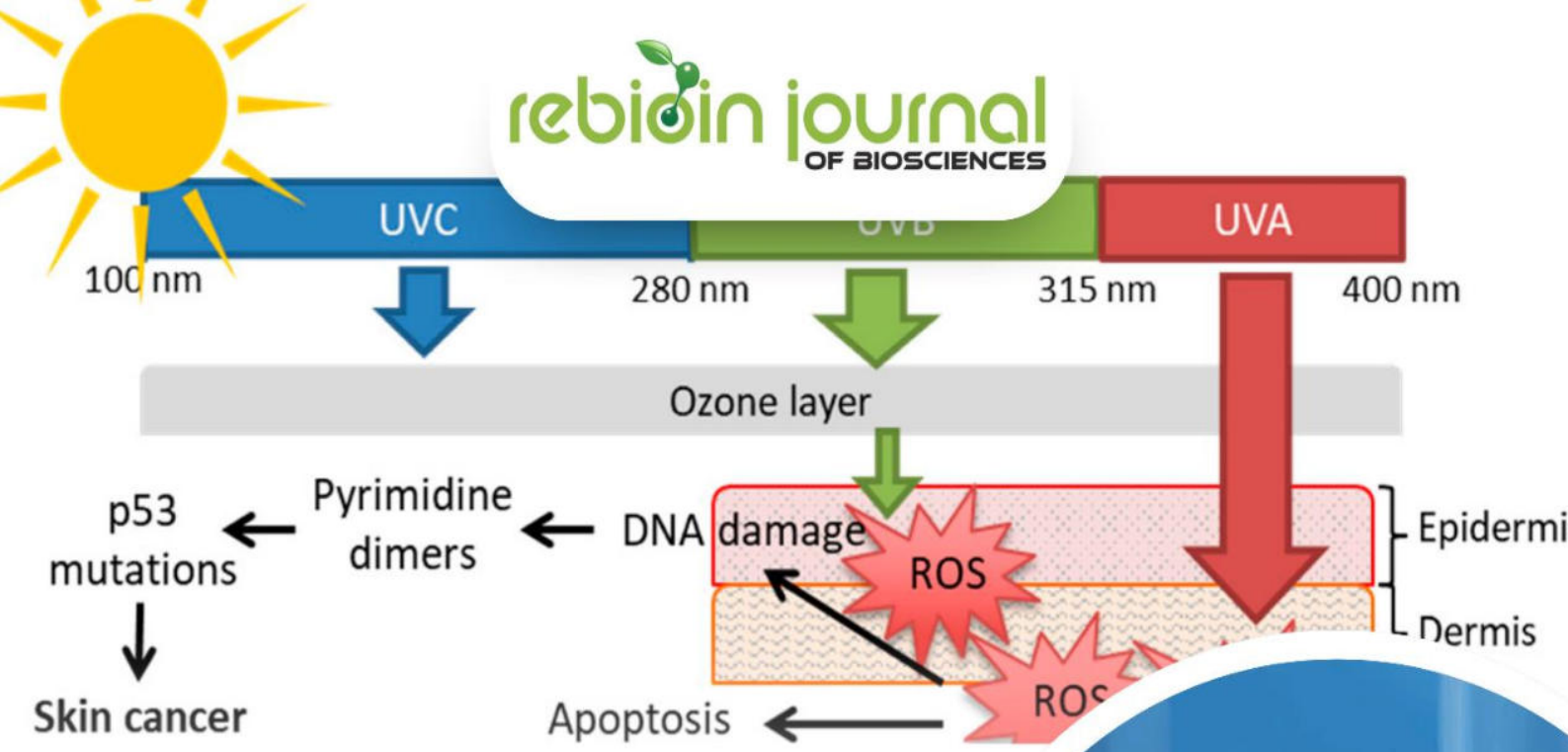

Beyond Sunscreens: Herbal Extracts as Next-Generation UV Filters for Skin Health

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Beyond Sunscreens: Herbal Extracts as Next-Generation UV Filters for Skin Health

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Abstract

In the modern era of escalating environmental stress, ultraviolet (UV) radiation has emerged as a significant global health concern due to its acute and chronic effects on human skin. Prolonged exposure to terrestrial solar UV radiation (100–400 nm), comprising UVA, UVB, and UVC, induces photochemical reactions that compromise skin barrier function, accelerate photoaging, and elevate the risk of malignancies. Epidemiological data indicate that solar UVR contributes to 50–70% of squamous cell carcinomas and 50–90% of basal cell carcinomas, with the World Health Organization reporting 2–3 million keratinocyte cancers and 132,000 melanoma cases annually worldwide. Beyond skin cancer, UV exposure triggers erythema, pigmentation, DNA damage, immunosuppression, and chronic dermatological conditions such as actinic keratoses and photoallergic reactions.

To mitigate these risks, UV protection strategies have been widely integrated into roofing, textiles, window glass, sunglasses, cosmetics, and pharmaceuticals. Conventional chemical and physical sunblocks (e.g., para-aminobenzoic acid, avobenzone, benzophenones, salicylates, and inorganic particles) provide broad-spectrum defense but raise concerns due to photoallergic reactions, reactive oxygen species (ROS) generation, systemic absorption, and environmental impact. These limitations underscore the urgent need for safe, sustainable alternatives.

In this context, natural bioactive compounds and herbal extracts have gained increasing attention as potential UV filters with added antioxidant and antimicrobial properties. Their integration into cosmetic formulations may offer effective photoprotection with minimal side effects and improved biocompatibility. This review explores the potential of herbal-based UV protectants as eco-friendly and sustainable alternatives to conventional sunblocks, emphasizing their multifunctional role in skin health and formulation development.

Keywords: Ultraviolet rays, keratinocyte cancer, melanoma

1.Introduction

In the modern era, where the Earth's atmosphere faces increasing environmental stresses, the importance of UV protection has become paramount. Prolonged exposure to harmful ultraviolet radiation can lead to a myriad of chronic and acute skin disorders, making it a pressing health concern for individuals worldwide [1]. The human skin, as the body's primary defense against external aggressors, is subjected to an extraordinary hostile environment over the course of a lifetime. The skin is the largest organ (16%of body mass) of our body, consisting of two primary layers epidermis and dermis [2]. Terrestrial Solar Ultraviolet radiation, a component of the solar spectrum, depending on wavelength, UVR (100-400nm) can be divided into three categories i.e. UVA (315-400nm), UVB (280-315nm) and UVC (100-280nm) can initiate detrimental photochemical reactions, causing both acute conditions such as erythema and chronic conditions such as photo-aging and skin cancers [3]. The penetration of UV radiation into the skin can have far-reaching consequences, compromising the skin's barrier function and contributing to premature aging, wrinkles, and an increased risk of malignancies [4]. It has been found that solar UVR is the leading cause of this, leading to 50–70% of all squamous cell carcinomas and 50–90% of all basal cell carcinomas. Statistics provided by the World Health Organization (WHO) indicate that as of 2018 there was a global incidence rate of 2–3 million keratinocyte skin cancers and 1,32, 000 melanoma skin cancers. The WHO has further stated that one in every three cancers, which are diagnosed, are some form of skin cancer [5]. Depending on spectrum and intensity of exposure, UV is responsible to cause various other issues as skin alterations, pigmentation, telangiectasias, DNA damage (activate p53 and p21), immunosuppression and apoptosis of keratinocytes (sunburn cells), phototoxic and photoallergic reactions, chronic exposure may lead to actinic keratoses, actinic cheilitis, malignant tumors on skin as cancer or rarely develop diseases such as solsr urticaria or polymorphous light eruption [6].

UV protection is crucial in various applications, including roofing, shielding materials, textiles, clothing, window glass, and sunglasses lenses, to reduce the harmful effects of ultraviolet (UV) radiation. In roofing, UV-resistant coatings and materials, such as reflective membranes, extend the lifespan of roofs by preventing degradation caused by prolonged sun exposure [7]. Shielding materials, including UV-protective films and coatings, are used in industrial and personal applications to block harmful radiation. UV-resistant textiles and clothing incorporate special dyes or fabric treatments that absorb or reflect UV rays, reducing skin exposure. Window glass with UV-filtering technology, such as laminated or coated glass, helps protect interiors from sun damage and reduces the risk of UV-related health issues. Similarly, sunglasses lenses with UV protection prevent eye damage, including cataracts and macular degeneration, by blocking UVA and UVB rays. These advancements highlight the importance of UV protection in everyday materials, ensuring long-term durability and health benefits.

Recognizing the gravity of this issue, the cosmetics and pharmaceutical industries have developed a range of synthetic medicines and cosmetics designed to provide UV protection. However, the use of chemical and physical sunblocks has raised concerns about their long-term safety and efficacy.But along with it lots of negative impacts are associated in use of organic and inorganic molecules as cosmetic product development , likewise photoallergic reaction, use of para-aminobenzoic acid, avobenzone, octocrylene, benzophenone compounds, octyl-triazone, salicylate in cosmetic product could generate ROS in human epidermis,application on large skin area and a prolonged use can affect skin viable cells, can travel to systemqatic circulation [8]. The search for novel, natural UV-screening compounds has gained attraction, as these alternatives hold promise for safe and sustainable protection against the harmful effects of solar radiation.In recent years, there has been growing concern regarding the safety and environmental impact of certain UV filters, prompting research into natural compounds and the development of eco-friendly alternatives. Regulatory bodies, such as those in the European Union, maintain specific lists of approved UV filters to ensure consumer safety and product effectiveness.

Regarding with these issues and concern in this review we have tried to develop sustainable, suitable UV protectant from herbal formulation and extracts with a minimal drawbacks and limited negative effects on skin . with this we can do further works regarding to develop the formulation quality which also have antioxidant and antimicrobial properties, along with it to develop a sustainable herbal formulation with UV protection activity.

2. Skin- The outer most protective layer

Skin the outer most protective covering of our body comprises of two primary layers that is epidermis and dermis, made with epithelial, mesenchymal, glandular and neurovascular systems. It's primary and basic function is to protect from environmental stress as like pathogens, chemical agents and UV [9-10]. Melanocytes, the only source of pigment in the skin, most of the melanin in the skin found in keratinocytes and function as a "natural sunscreen" to protect skin from UV photons, besides these melanin also have other physiological effects including regulatory effect on epidermal homeostasis, free radical scavenging for protection against oxidative injury and also have antimicrobial activity [11].

3. Ultraviolet Radiation-The UV Threat

Sun-rays is the continuous source of electromagnetic radiation that is divided into three major spectrum according to wavelength i.e. ultraviolet, visible and infrared. The UV rays is most significant spectrum of sunlight that causes photoaging, skin damage, pigmentation, irritation, redness as well as serious photo-damaging effects like skin cancer [12]. UVR is subdivided according to electro-physical properties into ultraviolet A (315-400nm) longest but least energetic but penetrates deeper into the dermis, ultraviolet B (280-315nm), ultraviolet C (100-280nm) photons having the shortest wavelength and each component of UV can exert a plenty of effects on cells, tissues and molecules (Fig. 1) [2].

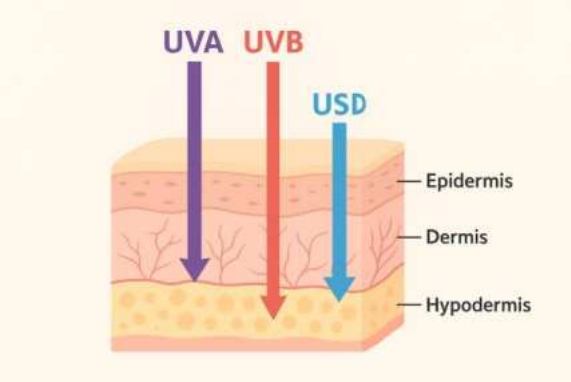

Fig 1. Layers of skin and penetration of UV into different layers of skin

4. Damaging Effect Of UV On Skin

Ultraviolet (UV) radiation, particularly UVA and UVB, is a major environmental factor responsible for a variety of skin damages, including premature aging, inflammation, and increased risk of skin cancers. Prolonged UV exposure leads to the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS), inducer of Superoxide radical, hydrogen peroxide and hydroxy radical, which can damage cellular DNA, proteins, and lipids, ultimately disrupting skin cell function and structure, also causes cutaneous agingas well as malignant tumors and various inflammatory disorder [13]. UVB rays primarily cause direct DNA damage, forming cyclobutane pyrimidine dimers (CPDs), which, if unrepaired, may result in mutations and carcinogenesis. UVA, while less energetic, penetrates deeper into the dermis and contributes to oxidative stress and photoaging. According to research by Matsumura and Ananthaswamy [14], UV radiation induces immunosuppression and cellular alterations that facilitate the development of non-melanoma and melanoma skin cancers. Additionally, Yaar and Gilchrest [15] emphasize that chronic UV exposure accelerates skin aging by degrading collagen and impairing the skin's structural integrity. These findings underscore the importance of photoprotection measures to mitigate UV-induced skin damage.

Major skin related issues discussed briefly as follows in Table 1.

Table.1. Showing Major Effects of UV damage on skin

Effect	Details
Sunburn	Caused by UVB, Skin redness, pain, inflammation
Photoaging	Wrinkles, leathery skin, loss of elasticity due to UV
Hyperpigmentation	Dark spots, freckles, uneven skin tone
DNA Damage	UVB causes thymine dimers in DNA, leading to mutations
Skin Cancer	Basal cell carcinoma, squamous cell carcinoma and melanoma
Immune Supression	Suppression of immune system of skin eventually due to UV

4.1. Skin Cancer

There are three main types of skin cancer: melanoma, basal cell carcinoma (BCC), and squamous cell carcinoma (SCC). BCC and SCC, collectively called non-melanoma skin cancers (NMSC), are usually non-lethal and treatable with surgery, so they are often not included in cancer registries. In contrast, melanoma is the deadliest type, with a case rate about one-tenth that of NMSC but causing roughly eight times more deaths. Melanomas originate from melanocytes, pigment-producing cells located at the base of the epidermis that transfer pigment to keratinocytes. BCC develops from basal cells, found at the bottom layer of the epidermis, which act as ski

n stem cells generating new keratinocytes. SCC arises from squamous cells, which are differentiated keratinocytes with a scale-like shape. Since both BCC and SCC derive from keratinocytes, they are sometimes referred to as keratinocyte cancers [16]. Solar ultraviolet (UV) radiation is a major cause of melanoma and non-melanoma

skin cancers, with oxidative stress playing a significant role in this process. Although in vivo data in humans are limited, evidence suggests that reactive oxygen species (ROS) contribute to photocarcinogenesis by inducing DNA damage and lipid peroxidation, both of which are linked to tumour progression [17].

The incidence of skin cancer is increasing by epidermic proportions, basal skin cancer remains the most common skin neoplasm. According to WHO One person dies of melanoma skin cancer every hours; between 2 and 3 million non-melanoma skin cancers and132,000 melanoma skin cancers occurs globally each year [18].

4.2. UV-Induced DNA damage

UV-induced DNA damage is a critical factor in the early stages of skin cancer development. When this damage is not repaired or the affected cells are not removed through apoptosis, DNA lesions can become mutagenic, potentially activating proto-oncogenes or inactivating tumor suppressor genes. The extent and type of DNA damage depend heavily on the wavelength of UV radiation. UVB (280–320 nm), the most energetic portion of sunlight reaching the Earth, primarily causes cyclobutane pyrimidine dimers (CPDs) and pyrimidine (6–4) pyrimidone photoproducts (64PPs). In contrast, UVA (320–400 nm), though less energetic, is more intense and also induces CPDs, along with various oxidative lesions such as single-strand breaks and oxidized bases—most notably 8-oxo-7,8-dihydroguanine (8-oxoGua), which is produced through multiple pathways. Studies show that sunlight mainly triggers the formation of pyrimidine dimers, aligning with the typical mutation patterns seen in skin cancers, while oxidative lesions like 8-oxoGua and strand breaks occur in lower amounts [19-20].

4.3. Oxidative stress Generation

UV radiation can generate reactive oxygen species (ROS), which may overwhelm the body's antioxidant defenses and lead to oxidative stress. This imbalance can cause cellular damage such as lipid peroxidation, DNA fragmentation, apoptosis, and cell death. UV light induces ROS either directly or through photosensitization, and it can disrupt cellular enzymes like catalase, increase nitric oxide synthase (NOS) activity, and reduce protein kinase C (PKC) expression, all contributing to elevated ROS levels. These effects depend on the cell's internal oxidant status, highlighting the importance of protecting against UV exposure to prevent harmful ROS-related damage.

Research indicates that skin responses to ultraviolet (UV) radiation vary significantly between individuals of European and Asian descent, primarily due to differences in constitutive pigmentation. A study published in the *British Journal of Dermatology* found that individuals with lighter skin types, often associated with European ancestry, exhibit a higher risk of developing skin cancers, including melanoma, and pigmentary disorders due to increased UV sensitivity. This increased sensitivity is attributed to lower melanin content, which correlates with greater DNA damage upon UV exposure. Conversely, research involving Thai participants demonstrated that constitutive skin color is a more reliable predictor of UV response than the Fitzpatrick skin type classification. This study revealed that individuals with darker skin tones, common in Asian populations, have a higher minimal erythema dose (MED), indicating greater resistance to UV-induced erythema. However, despite this increased resistance, significant DNA damage can still occur in darker skin tones, underscoring the importance of photoprotection across all skin types.

4.4. Harmful Reagents Used in Cosmetics

Cosmetic products often incorporate ultraviolet (UV) filters to protect the skin from harmful effects of UV radiation, which include photoaging, pigmentation, and increased risk of skin cancer. These UV filters are broadly categorized into chemical (organic) filters and physical (inorganic) particles. Chemical filters are classified into either UVA (benzopherones, anthranilates and dibenzoylmethanes) or UVB(PABA derivatives,salicylates, cinnamates and camphor derivatives) or Broad spectrum (ecamsule, silatriazole, bemotrizinol, bisoctrizole) [21]. Chemical filters such as oxybenzone (benzophenone-3), avobenzone, octinoxate (ethylhexyl methoxycinnamate), octocrylene, and homosalate absorb UV radiation and convert it into heat. These compounds are widely used due to their light texture and transparency on the skin. However, research indicates that some of these chemicals may pose dermatological and systemic risks along with it irritation and skin allergic reaction for sensitive skin, photo-instability, acne and clogging . For instance, oxybenzone has been associated with contact dermatitis and is considered a potential endocrine disruptor, mimicking estrogen in the body [22-23]. Similarly, octinoxate and homosalate have shown hormonal activity in laboratory studies, raising concerns about long-term exposure through daily cosmetic use [22].

In contrast, physical UV filters such as zinc oxide and titanium dioxide work by reflecting and scattering UV radiation. These are generally regarded as safer, especially for sensitive skin, and are often recommended for use in children and people with skin conditions. However, concerns have been raised about nano-sized forms of these particles, which are used to reduce the visible white cast on the skin. Studies suggest that nano-titanium dioxide and nano-zinc oxide can generate reactive oxygen species (ROS) upon UV exposure, which may lead to oxidative stress and DNA damage in skin cells [24-25]. Although the penetration of these nanoparticles through intact human skin is minimal, damaged or inflamed

skin may allow deeper absorption, potentially leading to cytotoxic effects [26]. Thus, while UV filters are essential for skin protection, their formulation and safety profile require careful consideration, especially in long-term cosmetic use.

5. Herbal Formulation-A Wide-range Revolution

Synthetic medicines and cosmetics, while offering rapid and visible results, are increasingly associated with long-term detrimental effects on skin health. Prolonged use of synthetic products containing compounds like parabens, phthalates, sulfates, and synthetic fragrances can disrupt the skin's natural barrier, induce oxidative stress, and promote chronic inflammation [27]. Such conditions accelerate collagen degradation, reduce skin elasticity, and contribute to premature aging manifestations such as fine lines, wrinkles, and hyperpigmentation [28]. Furthermore, several synthetic ingredients are recognized as endocrine disruptors, raising concerns about systemic toxicity with chronic exposure [29]. Over time, these effects compromise dermal structure integrity, leading to thinning of the skin and impaired regenerative capacity.

In contrast, replacing synthetic formulations with herbal cosmetics offers substantial benefits supported by emerging dermatological research. Phytochemicals derived from plants, such as flavonoids, terpenoids, and phenolic acids, exhibit strong antioxidant, anti-inflammatory, and collagen-stimulating properties without the adverse effects associated with synthetic chemicals [30]. In ancient civilizations, particularly within the traditional systems of Ayurveda, Siddha, and Unani medicine, herbs held a vital role in cosmetics and dermal applications. These systems emphasized the concept of beauty as an expression of inner health, where herbal treatments were used not only for enhancing appearance but also for promoting skin health and treating dermatological conditions. According to Ayurveda, herbs like turmeric (*Curcuma longa*), neem (*Azadirachta indica*), and aloe vera (*Aloe barbadensis miller*) were extensively employed for their anti-inflammatory, antimicrobial, and rejuvenating properties, which were believed to balance the body's doshas and enhance natural glow [30]. Similarly, Siddha medicine advocated the use of herbs such as *Acalypha indica* and *Vetiveria zizanioides* in formulations to purify the skin and slow aging. The Unani system focused on the temperamental theory, prescribing herbs like saffron (*Crocus sativus*) and rose (*Rosa damascena*) to maintain skin vitality and delay senescence by preserving the moist temperament of the skin. Long-term use of these herbal remedies is considered beneficial due to their high content of bioactive compounds like flavonoids, tannins, and essential oils, which provide antioxidant protection, improve skin elasticity, and promote collagen synthesis without the side effects associated with synthetic cosmetics (Table 2) [31]. Modern research has validated many of these traditional claims, highlighting the role of phytochemicals in anti-aging, wound healing, and photoprotection, thus supporting the prolonged dermal application of herbs as a safe and effective practice rooted in centuries-old wisdom [32].

Table 2: Showing plant phytochemical with a promising natural source of skin benefits

PHYTOCHEMICAL	SKIN BENEFITS
Flavonoids(e.g.quercetin,rutin)	UV Protection, Antioxidant, Anti-inflammatory
Polyphenols(e.g.catechins, resveratrol	Neutralize free radicals, prevent photoaging, Boost collagen synthesis
Carotenoids(e.g.beta-carotene,lycopene,lutein)	Protect against UV damage, Antioxidant, Improve skin tone
Phenolic acids	Stabilize vit C and E in formulation, Protect against oxidative stress
Tannins	Tighten skin
Saponins	Moisturizing, Skin elastacity, Cleanse pores
Alkaloids	Reduce puffiness, Improve circulation

Survey explores the effectiveness of herbal extracted cosmetics in improving skin health, based on user feedback and supporting literature. Synthetic skincare often contains harsh chemicals that can cause irritation, allergies, or long-term damage, while herbal cosmetics offer a natural, skin-friendly alternative. Enriched with plant-based compounds like *Aloe vera*, *Curcuma longa* (turmeric), *Azadirachta indica* (neem), and *Camellia sinensis* (green tea), these products are known for their antioxidant, anti-inflammatory, and antimicrobial benefits (Mukherjee et al., 2011). A structured survey was conducted among 100 participants aged 18–45, who used herbal skincare products for at least eight weeks. Results showed that 82% reported improved skin texture, 76% saw reduced acne, 68% noticed better hydration, and only 9% experienced mild side effects such as temporary redness. Additionally, 88% preferred herbal products over synthetic ones. These findings highlight the efficacy and safety of herbal formulations in promoting healthy skin with minimal drawbacks, making them a sustainable and beneficial alternative to conventional skincare products.

Herbal formulations offer effective UV protection, promote collagen retention, and improve skin health. They are safe for prolonged use, skin-friendly, and environmentally sustainable. These natural alternatives can successfully replace synthetic cosmetics, providing a holistic, gentle, and Eco-conscious approach to skincare.

6. Conclusion

The present study underscores the potential of herbal formulations as effective, safe, and sustainable alternatives to conventional synthetic skincare products. The survey findings revealed significant improvements in skin texture, hydration, and acne reduction among participants, with minimal adverse effects. Supported by literature, the inclusion of bioactive plant-derived compounds such as *Aloe vera*, *Curcuma longa*, *Azadirachta indica*, and *Camellia sinensis* provides multifunctional benefits, including antioxidant, anti-inflammatory, antimicrobial, and UV-protective properties. Unlike synthetic cosmetics, which often raise concerns of irritation, allergies, or long-term damage, herbal-based products offer a holistic and skin-friendly approach to maintaining dermal health. Furthermore, their environmental compatibility enhances their relevance in promoting eco-conscious skincare practices. Collectively, these findings establish herbal cosmetics as a promising and reliable choice for long-term skin health, combining efficacy with sustainability.

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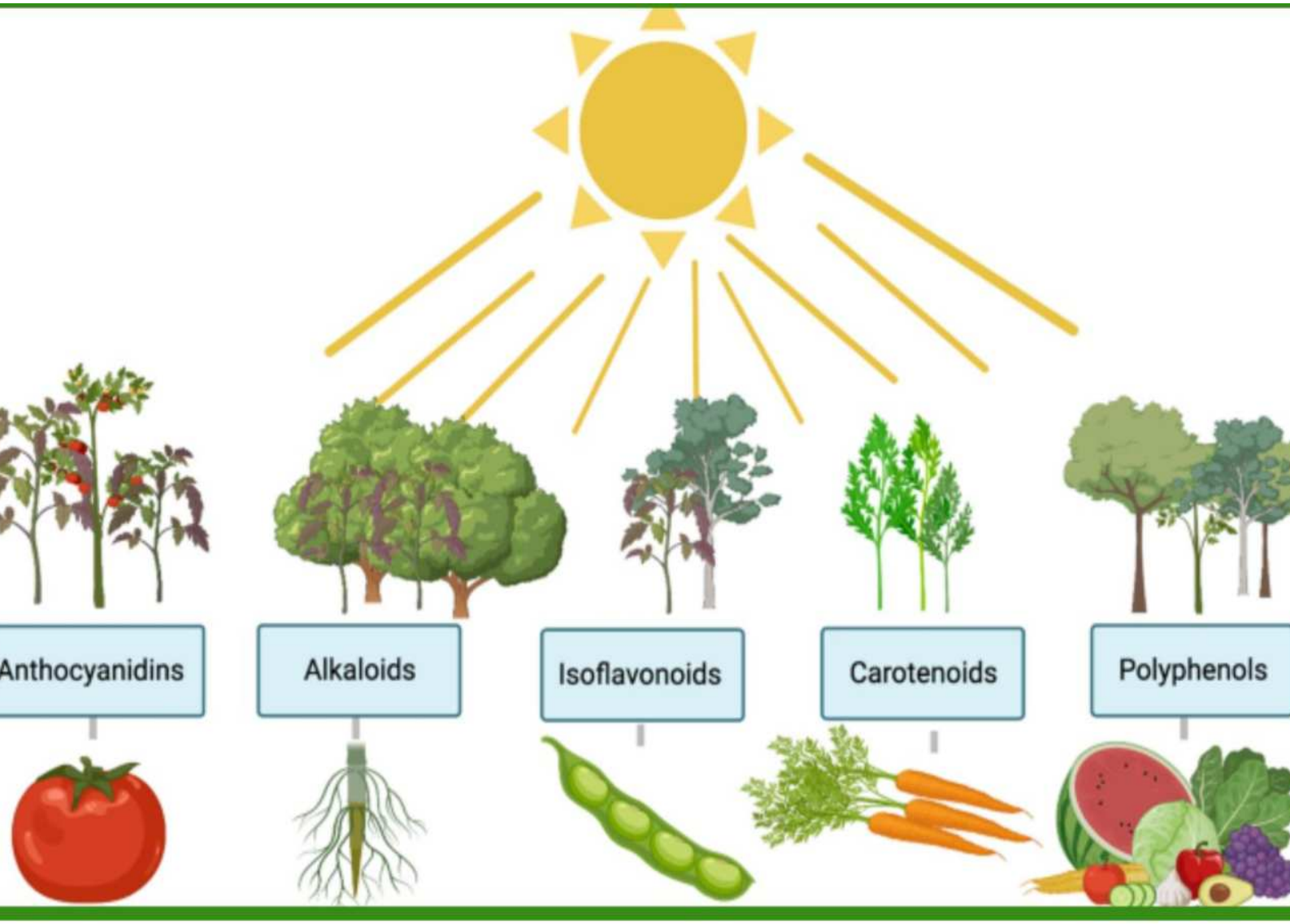
8. References

1. Singh HK, Kumar S, Bamne J, Taiwade K, Singh N, Chandel V, Haque FZ. Analyzing the synthesis of various inorganic nanoparticles and their role in UV-shielding. Materials Today: *Proceedings.* 2021; 46:5607-18.
2. D'Orazio J, Jarrett S, Amaro-Ortiz A, Scott T. UV radiation and the skin. *Int. J. Mol. Sci.* 2013; 14(6):12222-48.
3. Biniek K, Levi K, Dauskardt RH. Solar UV radiation reduces the barrier function of human skin. *Proc. Nat. Acad. Sci.* 2012; 109(42):17111-6.
4. Paulo MS, Adam B, Akagwu C, Akparibo I, Al-Rifai RH, Bazrafshan S, Gobba F, Green AC, Ivanov I, Kezic S, Leppink N. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of occupational exposure to solar ultraviolet radiation and of the effect of occupational exposure to solar ultraviolet radiation on melanoma and non-melanoma skin cancer. *Environment International.* 2019; 126:804-15.
5. Leiter U, Keim U, Garbe C. Epidemiology of skin cancer: update 2019. Sunlight, vitamin D and skin cancer. 2020; 123-39.
6. Gruber F, Peharda V, Kaštelan M, Brajac I. Occupational skin diseases caused by UV radiation. Acta Dermatovenerologica Croatica. 2007 Mar 1;15(3):0-.
7. Berdahl P, Akbari H, Levinson R, Miller WA. Weathering of roofing materials–an overview. *Construction and Building Materials.* 2008 Apr 1;22(4):423-33.
8. Gilbert E, Pirot F, Bertholle V, Roussel L, Falson F, Padois K. Commonly used UV filter toxicity on biological functions: review of last decade studies. International journal of cosmetic science. 2013 Jun;35(3):208-19.
9. Elwood JM, Jopson J. Melanoma and sun exposure: an overview of published studies. *Int. J. Cancer.* 1997 Oct 9;73(2):198-203.

10. Slominski AT, Zmijewski MA, Skobowiat C, Zbytek B, Slominski RM, Steketee JD. Melatoninergic system in the skin. *Sensing the Environment: Regulation of Local and Global Homeostasis by the Skin's Neuroendocrine System.* 2012; 16:27-36.
11. Wang A, Marino AR, Gasyna Z, Gasyna E, Norris Jr J. Photoprotection by porcine eumelanin against singlet oxygen production. *Photochem. Photobiol.* 2008 May;84(3):679-82.
12. Narayanan DL, Saladi RN, Fox JL. Ultraviolet radiation and skin cancer. *Int. J. Dermatol.* 2010; 49(9):978-86.
13. Ichihashi M, Ueda M, Budiyanto A, Bito T, Oka M, Fukunaga M, Tsuru K, Horikawa T. UV-induced skin damage. *Toxicology*. 2003; 189(1-2):21-39.
14. Matsumura Y, Ananthaswamy HN. Toxic effects of ultraviolet radiation on the skin. *Toxicol. App. Pharmacol.* 2004; 195(3):298-308.
15. Yaar M, Gilchrest BA. Photoageing: mechanism, prevention and therapy. *Br. J. Dermatol.* 2007; 157(5):874-87.
16. Liu-Smith F, Jia J, Zheng Y. UV-induced molecular signaling differences in melanoma and non-melanoma skin cancer. *Ultraviolet light in human health, diseases and environment.* 2017 Nov 9:27-40.
17. Sander CS, Hamm F, Elsner P, Thiele JJ. Oxidative stress in malignant melanoma and non-melanoma skin cancer. *Br. J. Dermatol.* 2003 May 1;148(5):913-22.
18. World Health Organisation(WHO): Skin cancers;available at :http://www.who.int/uv/faq/skincancer/en/index1.html, accessed 1st April 2014
19. Sinha RP, Häder DP. UV-induced DNA damage and repair: a review. *Photoch. Photobiol. Sci.* 2002;1(4):225-36.
20. Cadet J, Douki T. Formation of UV-induced DNA damage contributing to skin cancer development. Photochemical & Photobiological Sciences. 2018;17(12):1816-41.
21. Serpone N, Dondi D, Albini A. Inorganic and organic UV filters: Their role and efficacy in sunscreens and suncare products. *Inorganica Chim. Acta.* 2007 Feb 15;360(3):794-802.
22. Krause M, Klit A, Blomberg Jensen M, Søeborg T, Frederiksen H, Schlumpf M, Lichtensteiger W, Skakkebaek NE, Drzewiecki KT. Sunscreens: are they beneficial for health? An overview of endocrine disrupting properties of UV-filters. *Int. J. Androl.* 2012; 35(3):424-36.
23. Schlumpf M, Cotton B, Conscience M, Haller V, Steinmann B, Lichtensteiger W. In vitro and in vivo estrogenicity of UV screens. *Environ. Health Perspect.* 2001 Mar;109(3):239-44.
24. Noynek GJ, Lademann J, Ribaud C, Roberts MS. Grey goo on the skin? Nanotechnology, cosmetic and sunscreen safety. *Crit. Rev. Toxicol.* 2007; 37(3):251-77.
25. Shukla RK, Sharma V, Pandey AK, Singh S, Sultana S, Dhawan A. ROS-mediated genotoxicity induced by titanium dioxide nanoparticles in human epidermal cells. *Toxicol. Vitro.* 2011 Feb 1;25(1):231-41.
26. Monteiro-Riviere NA, Wiench K, Landsiedel R, Schulte S, Inman AO, Riviere JE. Safety evaluation of sunscreen formulations containing titanium dioxide and zinc oxide nanoparticles in UVB sunburned skin: an in vitro and in vivo study. *Toxicol. Sci.* 2011 Sep 1;123(1):264-80.
27. Draelos ZD, editor. Cosmetic dermatology: products and procedures. John Wiley & Sons; 2021 Dec 29.
28. Baumann L. Skin ageing and its treatment. *The Journal of Pathology: A Journal of the Pathological Society of Great Britain and Ireland.* 2007 Jan;211(2):241-51.
29. Darbre PD, Harvey PW. Paraben esters: review of recent studies of endocrine toxicity, absorption, esterase and human exposure, and discussion of potential human health risks. *J. App. Toxicol.* 2008; 28(5):561-78.
30. Mukherjee PK, Maity N, Nema NK, Sarkar BK. Bioactive compounds from natural resources against skin aging. *Phytomedicine*. 2011 Dec 15;19(1):64-73.
31. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: an overview. *Sci. World J.* 2013;2013(1):162750.
32. Sultana B, Anwar F, Ashraf M. Effect of extraction solvent/technique on the antioxidant activity of selected medicinal plant extracts. *Molecules.* 2009; 14(6):2167-80.



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